

Part I | Total 180 marks :part marking in brackets |

Paper I:

Time: 3hrs.

Full Marks: 60

- i) Origin of life (10)
- ii) Systematics (10)
- iii) Animal Diversity – Part 1: Nonchordates (40)

Paper II:

Time: 3 hrs.

Full Marks: 60

- i) Animal Diversity – Part 2: Chordates (40 marks)
- ii) Structural adaptation (10 marks)
- iii) Zoogeography (10 marks)

Paper III (Practical):

Time: 5 hrs.

Full Marks: 60

[Based on Paper I & II]

Part II [Total 280 marks: part marking in brackets]

Paper IV:

Time: 4hrs.

Full Marks: 90

- i) Cell Biology (25)
- ii) Molecular Biology (20)
- iii) Laboratory and Analytical Techniques (20)
- iv) Biochemistry (25)

Paper V:

Time: 4 hrs.

Full Marks: 90

- i) Genetics (20)
- ii) Basic Concepts of Immunology (20)
- iii) Animal Physiology (20)
- iv) Endocrinology and Reproductive Biology (30)

Paper VI (Practical):

Time: 5 hrs.

Full Marks: 50

[Based on Paper IV]

Paper VII (Practical):

Time: 5 hrs.

Full Marks: 50

[Based on Paper V]

Part III [Total 340 marks: part marking in brackets]

Paper VIII:

Time: 4 hrs.

Full Marks: 80

- 1. Histology and Histochemistry (25)
- 2. Developmental Biology & Teratology (25)
- 3. Adaptation & Evolution (30)

Paper IX:

Time: 4 hrs.

Full Marks: 80

- i) Ecology (25)
- ii) Environmental Biology & Toxicology(30)
- iii) Animal Behaviour (25)

Paper X:

Time: 4 hrs.

Full Marks: 80

- i) Applied Zoology (30)
- ii) Conservation Biology & Wild life (30)
- iii) General Informatics and Bio-informatics (20)

Paper XI (Practical):

Time: 4 hrs.

Full Marks: 50

[Based on Paper VIII & IX with emphasis on Methods of Field Biology]

Paper XII (Practical):

Time: 4 hrs.

Full Marks: 50

[Based on Paper X; Data handling (mainly biostatistics) and Field Work & Study
Report/Dissertation]

DETAILED DRAFT SYLLABUS FOR B.SC. HONOURS COURSE IN ZOOLOGY

Part I [Total 180 marks]

Paper I:

Time: 3hrs.

Full Marks: 60

- i) Origin of life
- ii) Systematics
- iii) Animal Diversity – Part I: Nonchordata

i) **Origin of life**

1. Theories of origin of life.
2. Chemical evolution: Miller's experiment, formation of complex organic molecules, protenoids.
3. Origin of organization: coacervates, microspheres, brief idea about origin of protein and nucleic acid, protocell, progenitor.

ii) **Systematics**

1. New trends in systematic (basic idea): Chemo and Serotaxonomy, Cytotaxonomy, Numerical taxonomy (Phenetics), Cladistics (Phylogenetic systematics).
2. Molecular systematic and DNA finger printing.
3. Nomenclature: Binomial and Trinomial nomenclature; International rules of Zoological nomenclature (brief account).

iii) **Animal Diversity – Part I: Nonchordata**

Five kingdom classification of living organisms

(a) Concepts of classification of animals (brief account): Classification based on number of cells, tissue or organ system level of organisation, development of germ layers, development of symmetry by cleavage, development of coelom, segmentation in the somite, development of mouth and digestive tract.

1. PROTOZOA

- (a) Characteristic features and classification of Kingdom Protista down to phyla.
- (b) Type study: *Paramecium*: morphology and structural organization [as revealed by compound microscopy]; locomotion, nutrition, excretion, osmoregulation and reproduction; conjugation in detail.
- (c) Comparative study of locomotion, nutrition, and reproduction in *Euglena*, *Paramecium*, *Plasmodium*, and *Amoeba*.

2. Metazoa: Brief idea about origin, compartmentalization, polarity, and cell specialization.

3. Phylum **PORIFERA**

- (a) Classification with reasons and example of Phylum Porifera down to subclasses.
- (b) Type study: *Scypha* sp.
- (c) General account of canal system and spicules.

4. Phylum **CNIDARIA**

- (a) Classification with reasons and example of Phylum Cnidaria down to subclasses.
- (b) Type study: *Obelia*
- (c) Polymorphism in reference to *Physalia*.
- (d) Types, distribution, ecology and conservation of coral reefs.

5. Phylum **CTENOPHORA**

- (a) Salient features and diversity of Ctenophora.
- (b) Type study: *Pleurobrachia*/ *Hormiphora*.
- (c) Affinities and systematic position (in brief).

6. Phylum **PLATYHELMINTHES**

- (a) Classification with reasons and example of Phylum Platyhelminthes down to classes.
- (b) Salient features of *Fasciola hepatica* and *Taenia solium*.
- (c) Life cycles and parasitic adaptations of *Fasciola hepatica* and *Taenia solium*.

7. Super Phylum **ASCHELMINTHES**

- (a) Highlight the heterogeneous nature of Super Phylum Aschelminthes.
- (b) Classification down to phyla.
- (c) Type study: *Ascaris lumbricoides*.

8. Salient features of **Pseudocoelomate Minor Phyla**: Gastrotricha and Rotifera.

9. Phylum **ANNELIDA**

- (a) Classification with reasons and example of Phylum Annelida down to classes.
- (b) Evolution and significance of segmentation.
- (c) General account of coelom, locomotion, and reproduction and development Annelida.

10. Salient features and phylogeny (in brief) of **Echiura** and **Sipuncula**.

11. Salient features and phylogeny of **Onychophora**.

12. Phylum **ARTHROPODA**

- (a) Classification with reasons and example of Phylum Arthropoda down to classes.
- (b) Salient features of Xiphosura.
- (c) Type study: *Periplaneta Americana*.
- (d) General accounts of exoskeleton, mouth parts, and vision in Arthropoda.
- (e) Metamorphosis in insects.

13. Phylum **MOLLUSCA**

- (a) Classification with reasons and example of Phylum Mollusca down to classes.
- (b) Type study: *Pila globosa*.
- (c) General accounts of mantle, shell, nervous system and sense organs in Mollusca.
- (d) Adaptive diversity of Cephalopoda.

14. Salient features of **Brachiopoda**, **Bryozoa** and **Chaetognatha**.

15. Phylum **ECHINODERMATA**

- (a) Classification with reasons and example of Phylum Echinodermata down to classes.
- (b) Origin of pentamerous symmetry.
- (c) General accounts of water vascular system and larva in echinodermata.

16. Phylum **HEMICHORDATA**

- (a) Salient features and phylogeny of Hemichordata.
- (b) Type study: *Balanoglossus*.

Paper II:

Time: 3 hrs.

Full Marks: 60

- i) Animal Diversity – Part II: Chordata (40 marks)
- ii) Structural adaptation (10 marks)
- iii) Zoogeography (10 marks)

i) Animal Diversity: Chordata

1. **Introduction:** Chordate characters [fundamental, general and advanced]; chordates versus nonchordates; diversity of chordates; classification down to subphyla; salient features of each subphylum.

2. **Subphylum UROCHORDATA**

- (a) Affinities; add a note on neoteny (paedogenesis) → *Amphibia*
- (b) *Ascidia* (morphology and retrogressive metamorphosis).

3. **Subphylum CEPHALOCHORDATA**

- (a) *Branchiostoma* [= *Amphioxus*] morphology, primitive, degenerate and specialized features (affinities and systematic position to be emphasized).

4. **Division AGNATHA**

Structural organization of *Petromyzon* [mention Ammocoete larva].

5. **Division GNATHOSTOMATA**

Super class **PISCES**

Class **Chondrichthyes** [cartilaginous fishes]

- (a) Classification with reasons and examples down to order (extant groups only).
- (b) Type study: *Scoliodon*.

Class **Osteichthyes** [bony fishes]

- (a) Classification with reasons and examples down to order (extant groups only).
- (b) Salient features, adaptation, and distribution of Dipnoi.
- (c) Accessory respiratory organs.
- (d) Parental care.

6. Class **Amphibia**

- (a) Classification with reasons and examples down to order (extant groups only).
- (b) Type study: *Duttaphrynus* (= *Bufo*) *melanostictus*.
- (c) Parental care.
- (d) Defense mechanism.

7. Class **REPTILIA**

- (a) Classification with reasons and examples down to Suborder (extant groups only).
- (b) Salient features of *Calotes versicolor*.
- (c) Salient features, habit and habitat of 'Big Fours' of Indian snakes.
- (d) Poison apparatus, types of venom, and First Aid to snake bite.

8. Class **AVES**

- (a) Classification with reasons and examples down to Superorder (extant groups only) and some specified Order as: Sphenisciformes, Ciconiformes, Anseriformes, Falconiformes, Galliformes, Psittaciformes, Apodiformes, Piciformes, and Passeriformes.
- (b) Type study: *Columba livia*.

9. Class **MAMMALIA**

- (a) Classification with reasons and examples down to Order (extant groups only) with special reference to Monotremata, Marsupialia, Chiroptera, Primates, Cetacea, Sirenia, Artiodactyla, Perissodactyla, and Proboscidea .
- (b) Dentition in mammals.
- (c) Exoskeletal structures of mammals.

10. Comparative study of brain, heart, aortic arches, and kidney among different classes.

ii) **Structural Adaptations**

- 1. Fossorial adaptation.
- 2. Scansorial adaptation.
- 3. Cursorial adaptation.
- 4. Aerodynamics in birds
- 5. Echolocation in mammals.

iii) Zoogeography

1. Animal Distribution: Cosmopolitan distribution, discontinuous distribution, bipolar distribution and isolated distribution.
2. Barriers to animal distribution: Physical barriers (topographical and climatic); biological barriers.
3. Zoogeographical realms and their characteristic fauna (reptiles, birds and mammals only) with special reference to Oriental realm.

Paper III (Practical): [Based on Paper I & II]

Time: 5 hrs.

Full Marks: 60

1. Study of the parts of a compound microscope, its proper use and Maintenance.
2. Construction of taxonomic key – for insect and fish (upto order).
3. (a) Preparation of world map to show six zoogeographical realms.
(b) Preparation of world map to show Wallace line, Weber line and Wallacea
(c) Locate the distribution of following animals in the world map:
Peripatus, Lung fishes, *Sphenodon*, Ratite, Hummingbirds (family Trochilidae), Hornbills, Monotremes, Marsupials, Armadillos, *Alligator*, *Gavialis*, Ant-eaters (Edentata), Pangolins, Elephant, Rhinoceros, Lion, Tiger, Camel, armadillo (Tubulidentata), lemur.
4. Identification with reasons (Non-chordata) (Preserved specimens/models/pictures as available to be used):
Paramecium, *Amoeba*, *Euglena*, *Vorticella*, *Scypha*, *Hyalonema*, *Spongilla*, *Hydra*, *Obelia*, *Aurelia*, *Metridium*, *Physalia*, *Valella*, *Fungia*, *Gorgonia*, *Fasciola*, *Taenia solium*, *Echinococcus*, *Ascaris*, *Sipunculus*, *Neanthes*, *Aphrodite* (Sea mouse), *Chetopterus*, *Metaphire*, *Tubifex*, Hirudinaria, Echiura (Spoon worm), *Sipunculus* (Peanut worm), *Peripatus*, *Carcinoscorpius* (horseshoe crab), *Lepas*, *Balanus*, *Sacculina*, *Eupagurus*, Prawn, Crab, Millipede, Scorpion, *Lepisma* (silverfish), *Scirpophaga*, *Helopeltis*, *Belostoma*, Cicada, Mantis, Chiton, Patella, *Sepia*, *Loligo*, *Octopus*, Sea Lily, Star fish, Brittle star, Sea cucumber, Sea urchin, *Balanoglossus*.
Larva: Ephyra, Nauplius, Zoea, Mysis, Megalopa, Glochidium, Trochophore, Veliger, Bipinnaria.
5. Identification with reasons (Preserved specimens/models/pictures as available to be used):
Ascidia, *Salpa*, *Doliolum*, *Branchiostoma*, *Myxine*, *Petromyzon*, *Scoliodon*, *Sphyrna*, *Trygon*, *Narcine*, *Cynoglossus*, *Catla catla*, *Labeo rohita*, *Cirrhina mrigala*, *Clarias batrachus*, *Heteropneustes fossilis*, *Anabus testudineus*, *Anguilla bengalensis*, *Hippocampus*, *Exocoetus*, *Ichthyophis*, *Hyla*, *Rhacophorus*, *Ambystoma*, *Chamaeleon*.

Gekko, *Calotes*, *Draco*, *Hydrophis*, *Naja*, *Vipera russelli*, *Bungarus caeruleus*, *Echis carinatus*, *Crotalus*, Lesser whistling teal, Pintail, Ruddy Shelduck, Brahminy kite, Shaheen falcon, Indian Longbilled vulture, Siberian crane, Bronzewinged Jacana, Great Indian bustard, Pied kingfisher, Blue Jay/Roller, Redbreasted Parakeet, Hill Myna, Purple Sunbird, Flying Squirrel, Clouded Leopard, Fishing Cat, Musk Deer, Nilgiri Tahr, Lion-tailed Macaque, Hoolock Gibbon.

Larva: Ammocoete, Tadpole, Axolotl.

6. Identification of Bones:

Fish: Precaudal and caudal vertebrae.

Amphibia: All axial and appendicular bones of toad.

Reptilia: Skull of *Chelonia*, *Calotes*, and poisonous snake; atlas, precaudal and caudal vertebrae of snake.

Bird: All axial and appendicular skeleton of *Columba*.

Mammal: All axial and appendicular skeleton of *Cavia*; skull of *Canis*.

Part -II (280 marks)

Paper IV:

Time: 4hrs.

Full Marks: 90

- i) Cell Biology
- ii) Molecular Biology
- iii) Laboratory and analytical Techniques
- iv) Biochemistry

i) Cell Biology

1. Cell as a unit
2. Structure & function of cell membrane
3. Structure and function of Intracellular organelles: Nucleus, Mitochondria, Lysosome, Peroxisome, Vacuoles, Endoplasmic reticulum, Cytoskeleton
4. Cell cycle: Steps of cell cycle, their regulation, mitosis and meiosis.

ii) Molecular Biology

1. Structure of Nucleic acids: DNA, RNA.
2. DNA replication, recombination, repair.
3. RNA synthesis and processing.
4. Protein synthesis and post translational modification.

iii) Laboratory and Analytical Techniques

1. Gene cloning and genetic engineering.
2. Cell & tissue culture techniques.
3. Transgenic animal & strain identification technique (Brief idea only).
4. Biosensors and their applications.
5. Colorimetry, Spectrophotometry, separation technique: cell fractionation. (homogenization and centrifugation), chromatography (Paper & TLC and HPLC), electrophoresis (SDS-PAGE, Agarose gels) (principle and uses/application only).

iv) Biochemistry

1. Concept of pH: Henderson-Hasselbalch equation
2. Structure and function of basic biomolecules: Carbohydrates, lipids, protein
3. Molecular bonds and forces of interactions: Van der Waals, electrostatic, hydrogen bonding, covalent bond, hydrophobic and hydrophilic interaction

4. Glycolysis, Oxidative Phosphorylation, Energy transducers
5. Enzymes, mechanism of enzyme catalysis
6. Conformation of nucleic acids, t-RNA, micro-RNA
7. Metabolism of carbohydrates, lipids, aminoacids, nucleotides

Paper V:

Time: 4 hrs.

Full Marks: 90

- i) Genetics
- ii) Basic concepts of Immunology
- iii) Animal Physiology
- iv) Endocrinology and Reproductive Biology

i) Genetics

1. Mendelism, Crossing Over, Linkage.
2. Extra-chromosomal inheritance.
3. Concept of gene: Allele, Multiple Allele, Pseudoallele and Complementation Test.
4. Sex determination & Barr body.
5. Human Genetics: Syndromes (Turner, Klinefelter, Patau, Marfan and Cat-cry), Inborn errors) Phenylketonuria, Alcaptonuria, Albinism, Multifactorial Diabetes.

ii) Basic concepts of Immunology

1. Innate & adaptive immunity.
2. Cell mediated & Humoral immunity.
3. B & T cells, cell mediated effector functions.
4. Autoimmunity, hypersensitivity.
5. Immune response to virus (HIV), Bacteria (T.B.) & Parasite (Plasmodium).
6. Vaccines & their success in human health management.

iii) Animal Physiology

1. Digestion & absorption mechanism.
2. Blood cells, Hemopoiesis, plasma function.
3. Heart tissue, cardiac cycle, regulation of heart beat, ECG-principle.
4. Positive, negative & double respiration; exchange & transport of gases.
5. Gross anatomy of brain & spinal cord, central peripheral nervous system & function; nervous transmission of impulse.
6. Types of kidney & mechanism elimination of nitrogenous wastes. Regulation of water balance by excretory system in representative fish, amphibian, reptilian, bird, mammal.
7. Endocrine glands, basic mechanism of hormone action.

8. Temperature regulation in Mammals (role of hypothalamus).

iv) Endocrinology and Reproductive Biology

1. Neuroendocrine organs and hormones in insects and crustaceans.
2. Vertebrate endocrinology: i) Classification of hormones, Endocrine glands (Pituitary, Adrenal, Pineal, Thyroid, Parathyroid, Gastro-intestinal, Pancreas, and Gonadal) and their hormones (brief account).
3. Concepts of neurosecretion: Hypothalamus, Hypophyseal interactions, Hypothalamus releasing and inhibiting hormones.
4. Hormonal action: Mechanism of hormone action at the level of cell membrane (insulin); at the level of enzyme located in cell membrane (adrenaline and peptide hormones); at the level of organelles (thyroxine); at the level of genes (steroids); positive and negative feedback regulation; Hormone receptors.
5. Gametogenesis.
6. Endocrine regulation of Reproductive Physiology (Oestrous & Menstrual cycle).

Paper VI (Practical):

Time: 5 hrs.

Full Marks: 50

Tissue processing and Microtechniques:

1. Use of camera lucida, stage and ocular micrometer for cell drawing, measurement and magnification calculation.
2. Cell culture (paramecium).
3. Tissue homogenization (Chick liver) and centrifugation.
4. Tissue preparation for histological study (fixation to cutting), Staining of histological tissues.

Molecular Biology:

1. Qualitative isolation of DNA from goat liver by Mamur's Method.
2. Estimation of DNA by Diphenylamine reaction.

Histological and Analytical Techniques:

1. Histochemical Techniques: PAS for carbohydrate, Fuelgen Reaction for Nucleic acid.
2. Paper chromatography and thin layer chromatography for amino acids separation.
3. Double staining of histological tissue: Ileum, liver, pancreas, thyroid, kidney, testis, ovary; and their identification.

Biochemistry:

1. Qualitative detection of specific carbohydrates, proteins and fats.
2. Quantative estimation of total proteins by Lowry's Method.
3. Quantative estimation of Carbohydrate (by Anthron Reagent) (Chick liver).
4. Quantative estimation of cholesterol.

Paper VII (Practical):

Time: 5 hrs.

Full Marks: 50

Genetics:

1. Study of meiosis from grasshopper testis.
2. Preparation and identification of Barr body.
4. Pedigree analysis.

Immunology:

1. Separation of lymphocytes from human blood.
2. ABO blood grouping and RH typing.

Physiology:

1. Estimation hemoglobin.
2. TC of RBC, WBC.
3. Differential Count.
4. Blood pressure detection (Auscultatory Method).
5. BT and CT (Capillary Method).

Part III [Total 340 marks]

Paper VIII:

Time: 4 hrs.

Full Marks: 80

- i) Histology and Histochemistry
- ii) Developmental Biology & Teratology
- iii) Adaptation, behaviour & Evolution

i) Histology and Histochemistry

- 1. Kinds of major tissue types and their function.
- 2. Histological details and function of Liver, Pancreas, Adrenal, Kidney, Testis, Ovary, Thyroid.
- 3. Tissue Fixatives: additive and non-additive, composition of common fixatives used for chromosome preparation, for protozoans, for organs meant for histological study, cryopreservation.

iv) Developmental Biology & Teratology

- 1. **Fertilization:** External fertilization, prevention of polyspermy, and activation of egg metabolism in Sea Urchins ; capacitation and prevention of polyspermy in mammal.
- 2. **Types of eggs:** Classification of eggs based on: the amount of yolk (micro, meso & macrolecithal), the distribution (iso, centro & telolecithal), presence or absence of shell (cleidoic & non-cleidoic) with examples; egg membranes (primary, secondary, tertiary).
- 3. **Cleavage:** Types of cleavage with examples – based on planes (meridional, vertical, equatorial & latitudinal); based on amount of yolk (holoblastic & meroblastic); based on development (determinate & indeterminate); based on pattern (radial & spiral).
- 4. **Development of Frog:** Cleavage, blastulation & fate map, Gastrulation, Neurulation and notochord formation, mesoderm and coelom formation, hormonal control of metamorphosis.
- 5. **Development of Chick:** Structure of egg, cleavage, blastulation and fate map, gastrulation, development and functions of extra embryonic membranes; development of heart, kidney and eye.
- 6. **Placentation:** Types, physiology and functions.
- 7. **Parthenogenesis:** Definition, types (Facultative, obligatory, cyclic and complete, arrhenotoky, thelytoky and artificial) and significance.
- 8. **Teratology:** Environmental disruption of animal development (alcohol, drugs, Nicotine and chemicals).

iii) Evolutionary Biology & Protective Adaptation

1. **Theories of evolution:** Lamarck's theory and its criticism, Neolamarckism; Darwin's theory and its criticism, Neo Darwinism.
2. **Modern concepts of evolutionary forces:** Genetic basis of evolution, genetic drift, punctuated equilibrium, Hardy-Weinberg equilibrium.
3. **Nature of evolution:** Adaptive radiation and Divergent evolution (Darwin's finches), Convergent evolution, Preadaptation.
4. **Evolution of Horse.**
5. **Colouration, mimicry and their survival value.**
6. **Speciation, Isolation.**

Paper IX:

Time: 4 hrs.

Full Marks: 80

- i) Ecology
- ii) Environmental Biology & Toxicology
- iii) Animal Behaviour

i) Ecology

1. Ecosystem Ecology and Energetics: Energy flow and energetics of ecosystem; Energy transformations and energy transfer; Laws of thermodynamics.
2. Biogeochemical cycles: Gaseous cycle - carbon and nitrogen cycles; sedimentary cycle.
3. Limiting factors: Basic concepts - Leibig's law of minimum - Shelford's law of tolerance, combined concept of limiting factors.
4. Population Ecology: Properties of population - density, natality, mortality, age distribution, biotic potential, environmental resistance and carrying capacity, population growth forms, J and S shaped curves, migration, emigration and immigration.
5. Community Ecology: Biotic community - definition, characteristics and classification, species diversity, fluctuations, stratification, succession, ecotone and edge effect.
6. Population interactions: Intraspecific and interspecific associations - Positive and negative interactions: Mutualism, Commensalism, Parasitism, Predation, and Competition.

ii) Environmental Biology and Toxicology

1. **Pollution:** Source and effects of major pollutants of air, water and soil.
2. **Toxicants and Public health hazards**
 - (a) Toxic chemicals (pesticides, automobile emissions, heavy metals, fertilizers, food additives, xenobiotics, endocrine disrupters, radioactive wastes).
 - (b) Levels of toxicity- Acute, sub acute, chronic, LD 50, LC 50
 - (c) Common bacterial poisoning (botulism).
3. **Man and Environment**

- (a) Sustainable development (in brief)
- (b) Destruction of habitat and its consequences - wetland, paddy fields, forest, river encroachment, ecological impacts of tourism.

iii) Animal Behaviour

1. Brief history, scope and branches.
2. Patterns of behavior:
 - (a) Innate behaviour (orientation taxes/ kinesis), simple reflexes and instincts, motivation;
 - (b) Learned behaviour - habituation, conditioned reflex, trial and error learning; latent learning, imprinting, insight learning, memory and learning.
3. Biological clocks / rhythms: Photoperiod, circadian rhythm; migration, navigation and homing instinct; diapause, hibernation and aestivation (in brief).
4. Animal communication: Communication by sound (bird's song, echolocation in marine mammals); communication by pheromones; bee dance.
5. Sociobiology: Social group in termites; altruism; kin selection; territoriality.

Paper X:

Time: 4 hrs.

Full Marks: 80

- i) Applied Zoology
- ii) Conservation Biology & Wildlife
- iii) General Informatics and Bio-informatics

i) Applied Zoology

1. Industrial zoology: Essentials of Aquaculture (Fish & Shrimp), Sericulture (Mulberry silk & Muga silk), Apiculture, poultry (Chicken).
2. Sustainable utilization of Biodiversity resource.
3. Breeding livestock (Cow, goat), marker assisted selection .
4. Production of transgenics & their use in health & agriculture.
5. Tissue & cell culture, immunological considerations for production of vaccines.

ii) Conservation Biology & Wildlife

1. Causes of loss of Indian wildlife; current status of threatened mammals, birds, reptiles, amphibians, butterflies from India.
2. Principles of conservation and management of endangered species.
3. Case study of conservation projects on Tiger, Rhinoceros, Lion, Hoolock gibbon.
4. State diversity Board, National Biodiversity Authority, Convention on Biodiversity.
5. Wildlife Sanctuary, National park, biosphere reserve: objectives and process of creation.

iii) General Informatics and Bio-informatics

1. PCR, polymorphism (DNA fingerprinting), bio polymer.
2. Chemo-informatics & chemical space, bio pesticides.
3. Databases and Database Analysis, Primary Databases (Nucleotide sequence. databases – Mention EMBL, DDBJ, Genbank; Protein sequence databases – Mention Swiss Prot, PIR, MIPS).
4. Data acquisition and data analysis.
5. NCBI, EBI, molecular graphic software (RasMol, Clustal X).

Paper XI (Practical):

Time: 4 hrs.

Full Marks: 50

1. Study of developmental stages of toad embryo.
2. Preparation and identification of whole mounts of chick embryo (24, 48, 72 & 96 hrs).
3. Preparation & identification of histological sections (mammalian) of liver, pancreas, thyroid, testes, ovary, lung, tongue, stomach (cardiac), ileum, skin.
4. Identification of queen, drone worker honey bee.
5. Estimation of dissolved O₂ using Winkler method (in pond and tap waters).
6. Estimation of dissolved CO₂ in pond and tap waters.
7. Estimation of alkalinity of pond and tap waters.
8. Extraction of soil organism by hand picking/sieving, floatation and Berlese funnel method.
9. Study of freshwater planktons.
10. Study of LD₅₀, LC₅₀ of small fish using CuSO₄.

Paper XII (Practical):

Time: 4 hrs.

Full Marks: 50

1. Field visit to a Sanctuary/National Park/Sea Shore/Krishi Vikash Kendra/Tea plantation or agricultural land and prepare a report on its resource and their use.

OR

- Visit any one farm (fishery/poultry/sericulture/apiary/lac culture) and prepare a comprehensive report on that basis.
2. Dissertation work documenting the biodiversity resource of a block where the college or the residence of the student is located.
 3. Knowledge of computer packages for statistical analysis of biodiversity data and graphical presentation of the same.
 4. Study infestation of pests in three different crop fields (at different locality) of paddy/jute/tea and compare the effect of pesticide/fertilizer/environmental factor statistically (χ^2 /t-test/multiple correlation/ANOVA) using SPSS or Minitab.

Proposed Revised Syllabus
B. Sc. ZOOLOGY (General)
University of North Bengal
(2014-15)

Distribution of Marks and Topic allotment

Part I [Total 150 marks]

Paper I:

Time: 2 hrs.

Full Marks: 50

1. Structural diversity of Non-chordates
2. Structural diversity of Chordates

Paper II:

Time: 2 hrs.

Full Marks: 50

1. Biochemistry
2. Cell Biology
3. Genetics

Paper III (Practical):

Time: 3 hrs.

Full Marks: 50

1. Mounting
2. Identification of Non-chordate, Chordate specimens
3. Identification of non-chordate sections
4. **Laboratory Note Book**
5. **Viva voce** (Based preferably on Practical set on the day)

Part II [Total 150 marks]

Paper IV:

Time: 2 hrs.

Full Marks: 50

1. Histology
2. Developmental Biology
3. Endocrinology
4. Immunology

Paper V:

Time: 2 hrs.

Full Marks: 50

1. Animal Physiology
2. Molecular Biology
3. Biotechnology

4. Biostatistics

Paper VI (Practical):

Time: 5 hrs.

Full Marks: 50

1. Identification with reasons: Endoskeleton, Histology, Embryological stages of Chick.
2. Identification of carbohydrate (Fehling, Benedict, Non-reducing sugar), of protein (Millon's and Biuret).
3. Collection / documentation of data of the experiments: Classification and tabulation of biological data
4. Presentation of data: Graphic representation: Histogram, Frequency Polygon and Frequency Curve; Diagrammatic representation: Line diagram, Bar diagram and Pie diagram
5. Analysis of data: (a) Measures of central tendency: Mean, Median and Mode
(b) Measures of Dispersion: Range, Mean deviation, SD and SE

6. **Laboratory Note Book**

7. **Viva voce** (Based preferably on Practical set on the day)

Part III [Total 100 marks]

Paper VII

Time: 3 hrs.

Full Marks: 60

1. Ecology
2. Evolution
3. Applied Zoology

Paper VIII (Practical):

Time: 4 hrs.

Full Marks: 40

1. **Identification:** Pre-stained Zooplanktons and Phytoplanktons.
2. **Slide preparation:** Staining and identification of prepared slides of Amphibian/mammalian organ (i.e. liver, kidney, intestine and skin) using Hematoxyline/Eosin stains.
3. Measurement of pH: (i) Colour chart method (ii) pH meter.
4. Preparation of blood/faecal smear:
 - a) Staining of blood film (Rabbit/Rat/Man); Identification of leucocytes and blood parasite; Study of T.C & D.C.
 - b) Faecal smear or rectal content of cockroach, toad, cow and study of organism therein.
5. Collection and identification of animals: Preservation of any 5 parasites and 5 pests (Major/Minor)
6. **Laboratory Note Book**
7. **VivaVoce** (Based preferably on Practical set on the day)

DETAILED DRAFT SYLLABUS FOR B.SC. GENERAL COURSE IN ZOOLOGY

PART 1 [150 Marks]

Paper I

Structural Diversity of Nonchordate and Chordate

Time: 2 hrs.

Full Marks: 50

1. General characters and classification of the under noted Phyla of Non-chordates with reasons and examples up to the level of sub-class
2. Structural organization and functions in details: General structure, locomotion, feeding, digestion, excretion, circulation, neural integration, reproduction and/or life history of the followings:
 - Protozoans: *Amoeba proteas*, *Entamoeba histolytica*, *Paramoecium caudatum*, *Plasmodium vivax* and *P. falciparum*
 - Porifera: *Scypha* sp
 - Cnidaria: *Obelia* sp and *Aurelia* sp
 - Platyhelminthes: *Fasciola hepatica*
 - Aschelminthes: *Ascaris lumbricoides*
 - Mollusca: *Pila globosa*, *Achatina fulica*
 - Annelida: *Metaphire posthuma* (Earthworm)
 - Arthropoda: *Periplaneta americana*
 - Echinodermata: *Asterias* sp
3. General characters and classification of Phylum Chordata. Classification with reasons and examples of vertebrate classes up to the level of order for Amphibia, Reptilia and upto the level of subclass for Chondrichthyes, Osteichthyes, Aves and Mammalia.
4. General organization, respiratory, circulatory, excretory, neuronal, reproductive structures, and function of *Branchiostoma*, *Scoliodon*, *Bufo*, *Calotes*, *Columba* and *Rattus*.
5. Comparative anatomy of gut, heart, kidney, brain of *Channa*, *Bufo*, *Columba* and *Rattus*.
6. Integumentary glands in mammals.
7. Scales in fishes.

Paper II

Biochemistry, Cell Biology and Genetics

Time: 2 hrs.

Full Marks: 50

1. Classification of Carbohydrate, Protein and Lipid.
2. Elementary idea about metabolism of Carbohydrate, Protein and Lipid: Concept of Glycolysis, TCA Cycle, elementary knowledge about electron transport, neoglucogenesis.
3. Vitamins: Sources and deficiency disorders for Vitamins-A, B-Complex, C, E and K.
4. Enzyme: Classification and brief idea about mechanism of Enzyme Action.
5. Ultrastructure and function of Plasmamembrane, GERL system, ribosome and mitochondria
6. Chromosome structure of nucleosome model

7. Cell cycle: brief ideas
8. Experimental proof of DNA as genetic material.
9. Autosomal and Sex-linked inheritance in Man: Thalassaemia and Haemophilia
10. Linkage: Definition, Incomplete and Complete (Experiment).
11. Crossing over (Genetic & Cytological proof).
12. Mutation: chromosomal changes (structural and numerical), point mutation, Down Syndrome, Klinefelter Syndrome.
13. Sex determination in *Drosophila* (Bridges Experiment only) and man.

Practical

Paper-III

Time: 3 hrs.

Full Marks-50

Staining/slide Preparation and Mounting:

Hydra, *Obelia* Colony, *Cyclops*, *Daphnia*, *Tubifex*, Salivary apparatus (with tongue) of cockroach, mouth parts of cockroach, Placoid, Cycloid and Ctenoid scales, Types of bird feather, Types and variety of mammalian teeth.

Spot Identification:

Non-chordates specimens up to subclass \ with scientific or common names of the specimen:

Amoeba, *Paramoecium*, *Euglena*, *Scypha*, *Hydra*, *Obelia*, *Aurelia*, Sea Anemone, *Taenia solium*, *Fasciola*, *Ascaris lumbricoides*, *Nereis*, *Metaphire* (Earthworm), *Chaetopterus*, *Hirudinaria*, *Macrobrachium*, *Squilla*, *Hippa*, *Balanus*, *Lepas*, *Cyclops*, *Daphnia*, *Periplaneta*, Locust, *Leptocoriza*, Scorpion, *Limulus* or *Carcinoscipians*, Millipede, Centipede, *Peripatus*, *Chiton*, *Aplysia*, *Pila*, *Achatina*, *Lamellidens*, *Loligo*, *Sepia*, Octopus, Star-fish, Sea-urchin, Sea-cucumber, *Balanoglossus*.

Spot Identification:

Chordate specimens upto order taxon with Scientific or common names of the specimens:

Branchiostoma, *Ascidia*, *Petromyzon*, *Myxine*, *Scoliodon*, Trygon, Narchine, Labeo, Catla, *Cirrhitina*, *Channa*, *Anabus*, *Heteropneustes*, *Clarias*, *Gymnophiona*, *Necturus*, *Hemidactylus*, *Chamelion*, *Draco*, *Naja*, *Columba* and *Cavia*.

Identification of Non-chordate sections/Specimens: Sections of Sponges (Syconoid and Leuconoid), LS of *Hydra*, LS of *Metridium*, CS Planaria, CS of Liver Fluke, CS of *Ascaris* (male & Female) through gonadal region, CS of *Metaphire* (Earthworm); Larvae: trochophore, glochidium, nauplius, pluteus.

Laboratory Note Book

VivaVoce (Based preferably on Practical set on the day)

Part-II [150 Marks]

Paper-IV: Histology, Developmental Biology, Endocrinology & Immunology

Time: 2 hrs.

Full Marks- 50

1. Histology of Pituitary, Thyroid, Adrenal and Pancreas and their hormonal functions in mammals.
2. Gametogenesis and fertilization.
3. Hormonal regulation of gametogenesis in males and females.
4. Cleavage and gastrulation in Amphibia.
5. Placenta: Types and Function.
6. Organizer concept.
7. Concept of Protostomia and Deuterostomia.
8. Endocrine glands and hormonal functions in mammals.
9. Endocrine glands and hormones- Classification of Hormones, Mechanism of Hormone action (Elementary idea).
10. Immunology: Innate and induced immunity
11. Cell mediated response, humoral response.
12. Concept of Antigen and Antibody; Vaccine & basis of its function.

Paper V: Animal Physiology, Molecular Biology, Biotechnology & Biostatistics

Time: 2 hrs.

Full Marks- 50

1. Formed elements in vertebrate blood, Clotting and Coagulation, ABO Blood group and Rh factor.
2. Respiration: Organs of respiration in Vertebrates, Properties and Functions of Respiratory Pigments: Transport of O₂ and CO₂.
3. Physiology of Nerve impulse and Synaptic transmission.
4. Structure of DNA, RNA (with reference to tRNA)
5. Mechanism of DNA replication, transcription and translation in Prokaryotes
6. Basic Concepts of Genetic Engineering: Restriction Enzyme, Plasmid Vector, Strategy for producing Recombinant DNA (with references to pBR322), Transformation (Prokaryotic host).
7. Scope of Genetic Engineering: Introduction, Cell cloning and application.
8. Biostatistics: Definition of Sample and Population: Frequency Distribution and Histogram.
9. Definition and calculation of Mean, Median, Mode, Standard Deviation & Standard Error (problems to be solved).

Practical

Paper-VI

Time: 5 hrs.

Full Marks-50

Identification of Vertebrate endoskeletons:

Toad: All skeletal parts including hyoid apparatus.

Pigeon: Skull, typical Cervical Vertebra, Synsacrum, Pygostyle with free Caudal Vertebra, Humerus, Carpometacarpus, half of Pelvic Girdle, Tibio-tarsus and Fibula, Tarsometatarsus.

Guineapig: Skull, Lower Jaw, Atlas, Axis, Thoracic and Lumbar Vertebrae, Scapula.

Identification with Reasons of Histological sections of: Stomach, Ileum, thyroid, Liver, Pancreas, Kidney, Testes, Ovary, Spleen, Lung.

Identification with Reasons of Embryological slides of: Chick developmental stages viz., 24, 48, 72, 96 hours of embryo.

Identification of carbohydrate (Fehling, Benedict, Non-reducing sugar), **of protein** (Millon's and Biuret).

Biostatistics: Problems to be set based on theory syllabus.

1. Collection / documentation of data of the experiments: Classification and tabulation of biological data
2. Presentation of data: Graphic representation: Histogram, Frequency Polygon and Frequency Curve; Diagrammatic representation: Line diagram, Bar diagram and Pie diagram
3. Analysis of data:(a) Measures of central tendency: Mean, Median and Mode
(b) Measures of Dispersion: Range, Mean deviation, SD and SE

Laboratory Note Book

VivaVoce (Based preferably on Practical set on the day)

Part-III [100 Marks]

Paper-VII: Ecology Evolution and Applied Zoology

Time: 3 hrs.

Full Marks- 60

Ecology

1. Components of Ecosystems.
2. Ecological Factors: Temperature, light, and their effects on organisms.
3. Population Ecology: Natality and Mortality; Growth forms; age pyramids; Distribution types; Regulation of Population Density.
4. Community Ecology: Characteristics; Types; Habitat and Niche concept.
5. Introduction to Animal Behaviour.
6. Importance of wild life study: Wild Life- Its importance. Introduction to major Indian mammals (big games), birds, reptiles (Crocodiles & snakes), and amphibians (Rana, Tylotriton, Caecilian). Fishes (major carps, murels & cat fishes of India), Concepts of Sanctuary, National Park, Concept of endemism, extinction risk & Conservation: *in situ* methods; *ex situ* methods.

Evolution

1. Zoolgeographical realms and their characteristic fauna with special reference to Oriental region.
2. Theories on the Origin of Life.
3. Lamarckism, Darwinism, Modern Concept of Evolution-Variation and Sources of Variation in a population, Hardy-Weinberg Equilibrium: Forces altering Hardy-Weinberg Equilibrium (Non-Random Mating, Mutations, Migrations, Genetic drift and natural selection): Founder effects and population Bottleneck.
4. Colouration and Mimicry and their adaptive significance.
5. Species: Definition, types: biological, sibling and polytypic.

Applied Zoology

1. **Poultry:** Definition of Poultry and introduction to poultry birds.
Chicken Poultry: Common Indigenous and Exotic breeds and their characteristics; Principles and management of Poultry including Poultry feed and Poultry diseases.
2. **Sericulture:** types of Indian Silk-moths and their food plants.
Mulberry sericulture: Important Races of *Bombyx mori* and their Voltinism; Cultivation of important varieties of Mulberry: Life History of *B. mori*; Diseases and their control; silk worm rearing and its required infrastructure.
Non Mulberry sericulture: An introduction to 'Tasar', 'Muga' and 'Eri' Cultures in India.
3. **Apiculture:** Introduction to Apiculture as an Industry; Names of four common Honey Bees: Organisation of a Bee colony: Modern frame Hive Method of Apiculture: Composition and use of Honey.

4. **Fisheries:** Basic ideas different Systems of Aquaculture-Monoculture-Polyculture, Raft Culture, Prawn Culture (Palacomonid and Penacid); Pearl culture. Some Common Disease- Protozoans, Fungal and Bacterial.
5. **Crop Pest Management:** Definition of Pest, Life History, Nature of Damage of the following pests:-
 - a. Paddy pests: *Scirpophaga incertulus*
 - b. Jute pest: *Anomis sabulifera*
 - c. Stored grain pest: *Sitophilus oryzae* (on rice)
 - d. Vegetable pest: *Trichoplusia ni* (Cabbage semilooper)
 - e. Tea pest: *Helopeltis theivora* (Tea mosquito bug)
6. **Fish and Cattle food:**
 Fish food: Types of processed feed-purified, semi-purified and practical. Formulation and preparation of fish food.
 Cattle feed: energy and nutritive value of feeds; common feed stuff of India; Processing of cattle feed.
7. **Study of Arthropod Vectors:**
 Arthropods are carriers of pathogens and parasites of man: a. Mosquito, b. Sandfly, c. House fly, d. Cyclops, e. Cockroach suggested control/ management programmes for the above carriers.

Practical

Paper VIII

Time: 4 hrs.

Full Marks- 40

1. **Identification:** Pre-stained Zooplanktons and Phytoplanktons.
2. **Slide preparation:** Staining and identification of prepared slides of Amphibian/ mammalian organ (i.e. liver, kidney, intestine and skin) using Hematoxyline/Eosin stains.
3. Measurement of pH: (i) Colour chart method (ii) pH meter.
4. Preparation of blood/faecal smear:
 - i) Staining of blood film (Rabbit/Rat/Man); Identification of leucocytes and blood parasite; Study of T.C & D.C.
 - ii) Faecal smear or rectal content of cockroach, toad, cow and study of organism therein.
6. Collection and identification of animals: Preservation of any 5 parasites and 5 pests (Major/Minor)
7. **Laboratory Note Book**
8. **VivaVoce** (Based preferably on Practical set on the day)

List of selected books for B.Sc. (General) and (Hons) in Zoology, NBU
(Please use the latest edition available)

Origin of life; Zoogeography and Evolution:

1. Rastogi, V.B. 1997. Evolutionary Biology: Kedar Nath Ram Nath Education Publishers
2. Hall B.K. and Hallgrimsson B. 2014. Strickberger's Evolution: 5th edition. - Burlington, MA : Jones & Bartlett Learning,
3. Futuyama, D. 2009. Evolution. Sinauer Associates, INC.
4. Tiwari, S. K. 1985. Zoogeography of India and South East Asia - CBS Pubs., New Delhi.
5. Cox, C.B. and Moore, P.D. 2009. Biogeography: an ecological and evolutionary approach -Wiley- Blackwell.
6. Chattopadhyay, S. 2002. Life: Origin, Evolution, Adaptation & Ethology -Books & Allied (P) Ltd.

Systematics

1. Mayr, E. and Ashlock, P. D. 1991. Principles of Systematic Zoology. 2nd Ed., McGraw-Hill.
2. Dalela, R. C. and Sharma, R. S. 1992. Animal Taxonomy. Jai Prakashnath & Co., Meerut.
3. Hillis, D. M., Moritz, C. and Mable, B. K. (eds) 1996. Molecular Systematics - Sinauer Associates, Sunderland, M.A.

Animal Diversity – Part 1: Nonchordates

1. Barnes, R. D. and Ruppert, E. E., 1994. Invertebrate Zoology. Brooks Cole.
2. Ruppert, E. E., Fox, R. and Barnes R. D. 2003. Invertebrate Zoology: a Functional Evolutionary Approach. Brooks Cole.
3. Barrington, E. J. W. 1981. Invertebrate Structure and function. ELBS and Nelson.
4. Sinha, K. S., Adhikari, S., and Ganguly, B. B. Biology of Animals. 2003. Vol. I. New Central Book Agency (p) Ltd. Kolkata.
5. Jorden, E.L. and Verma P.S. Invertebrate Zoology. 2013 (revised). S. Chand.
6. Brusca, C.R. and Brusca, G.J. 2002. Invertebrates. Sinauer Associates, Inc., Publishers, Sunderland
7. Pechenik J.A. 2000. Biology of Invertebrates, McGraw Hill International Edition
8. Anderson, D.T. 2001. Invertebrate Zoology - 2e, Oxford Uty. Press (Indian Edn.2006)

Animal Diversity – Part 2: Chordates and Structural adaptation

1. Sinha, K. S., Adhikari, S., and Ganguly, B. B. Biology of Animals. 2003. Vol. II. New Central Book Agency (p) Ltd. Kolkata.
2. Jorden, E.L. and Verma P.S. 2010. Chordate Zoology. S.Chand & Co. Ltd
3. Kardong, K. V. 2006. Vertebrates: Comparative anatomy, function evolution. Tata McGraw Hill.
4. Kotpal R.L. 1997. Modern text book of Zoology: Vertebrates, Rastogi Publications

5. Pough, H.F., Heiser J.B. and McFarland, W.N. 1990 and 1991. Vertebrate Life, Macmillan, NY
6. Ray, B. Bhattacharya, B.N., Basu, B and Ray, P. 2003. Zoology vol.I (rev. 2nd edition in Bengali). Abhinaba Prokashan, Kolkata-9
7. Sibley, C.G. and Ahlquist J.E. 1990. Phylogeny and Classification of Birds: A study in Molecular evolution. Yale Univ. Press. Yale.
8. Young, J.Z. 1981. The life of vertebrates. Butler and Tanner Ltd. Frome, Somerset, UK.
9. Hildebrand, M. and Goslow, G. 2002 Analysis of Vertebrate Structure , 5e, Wiley.

Cell Biology

1. Cooper, G. M. 2006. The Cell: A molecular Approach. Sinauer Associates Inc.
2. Lodish H., Berk A., Kaiser C., Krieger, M., Scott, M. P., Bretscher A., Ploegh H. and Matsudaira P. 2007. Molecular Cell Biology: Macmillan education
3. Karp, G. 2008. Cell and Molecular Biology: Concepts and experiments. John Wiley

Molecular Biology and Genetics

1. Russell P. J. 2005. iGenetics: A Mendelian approach.
2. Pierce B. A. 2005. Genetics A conceptual Approach. W.H. Freeman and Co.
3. Snustad, D. P. and Simmons, M. J. 2011. Principles of Genetics. John Wiley and Sons
4. Strickberger M.W. 2012. Genetics. Prentice Hall of India Pvt. Ltd., New Delhi.
5. Tamarin, R. H. 2004. Principles of Genetics. Tata McGraw-Hill Publishing Comp. Ltd.
6. Kothari, M.L. and Mehta, L.A. Roychoudhuri, S.S. 1999. (impression 2009) Essentials of Human genetics, University Press (India) Pvt. Ltd. Hyderabad
7. Singh, B.D. 2004. Fundamentals of Genetics, Kalyani Publishers, N.Delhi
8. Griffith, J.F., Wessler, S., Doebley, J. and Carroll, S.B. 2010. An introduction to genetic analysis- W H Freeman & Company
9. Klug, W.S., Cummings, M.R., Spenser, C.A. and Palladino, M.A. 2011. Concept of Genetics- Benjamin Cummings.
10. Lewin, B. and Krebs, J.E. 2011. Lewin's Gene X - Jones & Bartlett Learning, LLC.

Laboratory and Analytical Techniques

1. Friefelder, D. 2002. Physical Biochemistry. W. H. Freeman and Co.
2. Wilson, K., and Walker, J. (eds.) 2001. Principles and Techniques of Practical Biochemistry. Cambridge University Press.
3. Sadasivan, S. and Manickam, A. 2003. Biochemical Methods. New Age International Publishers.
4. Ruxton, G. D. and Colegrave, N. 2006. Experimental Design for Life Sciences - 2e, Oxford University Press.
5. Holmes, D., Moody, P. and Dine, D. 2006. Research Methods for the Biosciences - Oxford University Press.

Biochemistry

1. Nelson, D. L. and Cox. M. M. 2008. Lehninger's Principles of Biochemistry. Macmillan Worth Publishers.

2. Murray R., Bender D., Botham K.M., Kennelly P.J., Rodwell V., Weil P.A. 2012. Harpers illustrated Biochemistry: McGrawHill Education. India
3. Berg, J. M., Tymoczko, J. K. and Stryer, L. 2002. Biochemistry. W. H. Freeman and Company.
4. Das, D. 1980. Biochemistry: Academic Publishers
5. Boyer R. 2000. (5th impression 2009). Modern Experimental Biochemistry, Pearson Education.
6. Elliot, W.H. and Elliot, D.C. 2009. Biochemistry and Molecular biology- Oxford University Press.

Basic Concepts of Immunology

1. Goldsby, R. A., Kindt, T. J., Kuby, J. and Osborne, B. A. 2007. Immunology. W. H. Freeman and Co.
2. Chakraborty, A.K. 2014. Immunology and Immunotechnology: Oxford University Press. India
3. Pinchuk, G. 2002. Theory and Problems of Immunology, Tata McGraw Hill Publishing Co. Ltd. New Delhi.

Animal Physiology and Adaptation

1. Hall J.E. 2010. Guyton and Hall Textbook of Medical Physiology. Saunders
2. Barrett K.E., Barman S.M. Boitano S. Brooks, H.L. 2012. Ganong's Review of Medical Physiology. McGraw-Hill Medical
3. Randell, D. Burggren, W. French, K. 1997. Eckert's Animal Physiology: W.H. Freeman & Company, New York
4. Berry, A.K. 1997. A Text book of Animal Physiology, 6e, Emkay Publications, Delhi-51.
5. Schmidt-Nielsen, K. 1997. Animal Physiology: Adaptation and Environment – Cambridge University Press
6. Chaudhuri, S.K. 2002. Concise Medical Physiology (4th ed). New Central Book Agency (P) Ltd.

Endocrinology and Reproductive Biology

1. Hadley, M.E. and Levine J.E. 2009. Endocrinology. Dorling Kindersley (India) Pvt. Ltd. Pearson Education.
2. Bentley, P. J. 1998. Comparative vertebrate endocrinology - CUP.

Histology and Histochemistry

1. Verma, G.P. 2001. Fundamentals of Histology. New Age International (P) Ltd. Publishers

Developmental Biology and Teratology

1. Gilbert, S.F. 2000. Developmental Biology. Sinauer Associates.
2. Wolpert L. and Tickle C. 2011. Principles of Development. Oxford University Press
3. Balinsky, B.I. 2012. An Introduction to Embryology, 5th ed, Cengage Learning.
4. O'Rahilly & Muller; 2001. Human Embryology & Teratology, 3e – Wiley
5. Carlson, B.M. 2014. Human Embryology and Developmental Biology – Elsevier.

- Slack, J. M. W. 2013. *Essential Developmental Biology* - Wiley- Blackwell.

Ecology and Environmental Science

- Sharma, P.D. 1997. *Ecology and Environment*: Rastogi Publications, Meerut
- Dash, M. C. 2009. *Fundamental of Ecology*. Tata McGraw-Hill Company.
- Stiling, P. 2001. *Ecology- Theories and Applications*. Prentice Hall of India.
- Krebs, C.J. 1978. *Ecology: The Experimental Analysis of Distribution and Abundance*, Harper International Edition.
- Gaston, K. 1996. *Biodiversity, A biology of numbers and difference*, Blackwell Science.
- Santra S. C. 2010. *Fundamentals of Ecology and Environmental Biology*. New Central Book Agency (P) Ltd.
- Cunningham, W. and Cunningham, M. 2009. *Principles of Environmental Science*, 5e - TMH.
- Chatterjee, B. 2007 *Environmental Laws - Implementation Problems* - Deep & Deep Pubs.
- Kumar, A. 2004. *Textbook of Environmental Science* - APH Publishing Co., ND.
- Hawkins, R. E. 2001, *Encyclopedia of Indian Natural History* –BNHS/OUP.
- Primack, R. 2010. *Essentials of Conservation Biology* - Sinaur Associates
- Chapman J.L. and Reiss, M. 1998. *Ecology: Principles and Applications*, 2e - Cambridge Low Price Editions.
- Ramakrishnan, P.S. 2012. *Ecology and Sustainable Development* 2nd edition – National Book Trust India- Publication division Govt.of India
- Smith, R.L. and Smith, T.M. 2001. *Ecology and Field Biology: Hands-on Field Package*, 6e –Benjamin Cummings
- Molles, M.C (Jr). 2009. *Ecology: Concepts and Application* (4th ed). McGraw Hill (International Edition)

Wildlife

- Kothari, A.S. 2012. *Wildlife of the Himalayas and Terai region*. Bombay Natural History Society. Central Marketing Dept. Hornbill House. S.B. Singh Marg, Mumbai 400001.

Toxicology

- Pandey, K. and Shukla, J.P. 1992. *Elements of Toxicology*. D.K. Publishers Distributors P Ltd.

Biotechnology

- Singh B.D. 2000. *Biotechnology*: Kalyani Publiushers, New Delhi
- Balsubramanian, D. (Ed) 1992. *Concept of biotechnology*. Oxford Universities Press
- Kreuzer, H. and Mashev, A. 2007. *Molecular Biology and Biotechnology*- ASM Press
- Satyanarayana, U. 2008. *Biotechnology* –Books & Allied (P) Ltd.

Animal Behaviour

- Alcock, J. 2009. *Animal Behaviour: An Evolutionary Approach*. Sinauer Associates
- Drickamer, L.C., Vessey, S. and Jakob, E. 2002. *Animal Behaviour: Mechanisms, Ecology, Evolution*: McGraw-Hill Education.

3. Manning, A. and Dawkins, M.S. 1998. Essentials of Animal Behaviour. Cambridge Univ. Press.
4. Davies, N.B., Krebs, J.R., and West, S.A. 2012. An Introduction to Behavioural Ecology, 4e –Wiley-Blackwell.
5. Mandal F. B. 2010. Textbook of Animal Behaviour –PHI (EEE)

Bioinformatics:

1. Ghosh, Z. and Mallick, B. 2008. Bioinformatics: Principles and Applications. Oxford University Press. India
2. Rastogi, S.C. and Rastogi, M. P. 2005. Bioinformatics: Method & Applications. Genomics, Proteomics & Drug Discovery. Prentice Hall of India, New Delhi.
3. Xiong, J. 2006. Essential Bioinformatics - Cambridge University Press, India Pvt. Ltd.

Biophysics:

1. Daniel, M. 1989. Basic Biophysics for Biologists, Agro Botanical Publishers (India) Bikaner

Economic Zoology

1. David, B.V. and Ananthakrishnan, T.N. 2010. General and Applied Entomology. Tata McGraw Hill Education Pvt. Ltd. N. Delhi
2. Srivastava, K. P. 1996 (reprinted 2004). Applied Entomology vol. I and II. Kalyani Publishers
3. Dey, N.C., Dey, T.K., Dey Sinha, M. 2010. Medical Parasitology. New Central Book Agency (P) Ltd. Kolkata
- 4.

Practical:

1. Daniel, J.C. 2002. The Book of Indian Reptiles and Amphibians. Bombay Natural History Society. Oxford University Press.
2. Prater, S.H. 1971. The Book of Indian Animals. Bombay National. Oxford University Press.
3. Ali, S. 1996. The book of Indian Birds. Bombay Natural History Society. Oxford University Press.
4. Ghosh, K. C. and Manna, B. 2005. Practical Zoology. New Central Book Agency (P) Ltd. Kolkata.
5. Bhattacharyya, B.N. 2008. An Introduction to Ornithology and Biology of the Blue Rock Pigeon, New Central Book Agency (P) Ltd. Kolkata-9
6. Poddar, T., Mukhopadhyay, S. Das, S.K. 2003. An advanced Laboratory Manual of Zoology. MacMillan India Limited, Kolkata.
7. Thimmaiah S.K. 1999. Standard Methods of Biochemical Analysis. Kalyani Publishers, New Delhi. Reprinted 2004
8. Negi, K.S. 2006. Biostatistics. A.I.T.B.S. Publishers and Distributors (Regd.)
9. Rajathi, A. and Chandran, P. 2010. SPSS for you. MJP Publishers, Chennai
10. Khandpur, R.S. 2006. Handbook of Analytical Instruments. Tata McGraw-Hill Publishing Company Ltd.
11. Chainy, G.B.N. 2004. Basic Biostatistics, Kalyani Publishers, N. Delhi.